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Sec: A

Q stage discharge relationship for a concrete rectangular box culvert.

Given data:

Width = 1.4m
height = 0.9m
length = 28m
slop = 1: 1000

manning j n = 0.013

Spare edge entrance ; Ke = 0.5

Range = 0-3m

Sol:

H/D ≤ 1.4m
H < 0.9m

discharge is given by

$$Q = 2.92 Y_0 [1.2 y_0 / 1.2 + 2 y_0]^{2/3} \quad (4)$$

Critical depth ::

$$y_c = \left(q^2/g\right)^{1/3} \quad \text{— (A)}$$

$$q = Q/B \quad \text{— (B)}$$

by putting value in eq b

$$q_1 = Q_1/B = \frac{0.299}{1.4} = 0.213$$

$$q_2 = Q_2/B = \frac{0.785}{1.4} = 0.561$$

$$q_3 = Q_3/B = \frac{1.330}{1.4} = 0.95$$

putting value in eq (A)

$$y_{c1} = \left(q_1/g\right)^{1/3} = \left(\frac{(0.213)^2}{9.81}\right)^{1/3} = 0.166\,m$$

$$y_{c2} = \left(q_2^2/g\right)^{1/3} = \left(\frac{0.561^2}{9.81}\right)^{1/3} = 0.317\,m$$

$$y_{c3} = \left(q_3^2/g\right)^{1/3} = \left(\frac{0.95^2}{9.81}\right)^{1/3} = 0.451$$

Y_0 m	$Q(m^3 s^{-1})$	Y_c (m)
0.3	0.299	0.166
0.6	0.785	0.317
0.9	0.1330	0.451.

by putting value of y_0 we will get the corresponding discharge.

$$Q_1 = 2.92 (0.3) \left[\frac{1.2 (0.3)}{1.2 + 2 (0.3)} \right]^{2/3}$$

$$= 0.299 \, m^3/s$$

$$Q_2 = 2.92 (0.5) \left[\frac{1.2 (0.6)}{1.2 + 2 (0.6)} \right]^{1/3}$$

$$= 0.785 \, m^3/s$$

$$Q_3 = 2.92 (0.9) \left[\frac{1.2 (0.9)}{1.2 + 2 (0.9)} \right]^{2/3}$$

$$= 1.330 \, m^2/s$$

Y_0 m	H(m)	$Q(m^3 s^{-1})$
0.3	0.399	0.299
0.6	0.699.	0.785
0.9	0.999	1.330
Corbicent > 0.9 1.2D	1.08	⟶ 1.477 by Interpolation

$H/D \geq 1.4$

(a) for given flow

$$Q = C_d (1.4 \times 0.9) [2g (H - D/2)]^{1/2}$$

$$Q = 0.62 (1.4 \times 0.9) \left[2 (9.81) (1.08 - \tfrac{0.9}{2})\right]^{1/2}$$

$$\boxed{Q = 2.746\ m^3/s}$$

At the inlet

$$H = y_0 + \frac{U^2}{2g} + k_e \frac{U^2}{2g}$$

$$U_1 = 1.142\ m/s$$

So,

$$H_1 = y_{01} + \frac{U_2}{2g} + k_e \cdot \frac{U_2}{2g}$$

$$0.3 + \frac{(1.142)^2}{2(9.81)} + 0.5 \left(\frac{(1.142)^2}{2(9.81)}\right)$$

~~0.699m~~ 0.399m

$$H_2 = 0.96 + \frac{(1.142)^2}{2(9.81)} + 0.5 \left(\frac{(1.142)^2}{2(9.81)}\right)$$

$$\boxed{0.699m}$$

$H_3 = 0.9 + \frac{(1.142)^2}{2(9.81)} + 0.5\left(\frac{(1.142)^2}{2(9.81)}\right)$

$= 0.999m$

following table summarize the result.

H_m	$Q(m^3/s$	Type of flow
Rising stage.		
0.399	0.299	open channel
0.699	0.785	"
0.999	1.330	"
1.080	1.477	pipe flow
2.000	2.487	"
3.000	3.242	"
falling stages:		
2.000	2.487	pipe flow
1.080	1.477	"
0.999	1.330	"
0.699	0.785	open channel
0.399	0.299	"

the following result are obtained

H m	Q ($m^3 s^{-1}$)	V_0 (m)
1.08	2.746	≥ 0.9

For a pipe flow the energy equation gives:

$$H + S_0 L = D + h_L$$

where

$$h_L = k_e V^2/2g + (V n)^2 L / R^{4/3} + \frac{V^2}{2g}$$

thus

$$Q = 2.08 (H - 0.57)^{1/2}$$

during rising stage the flows fully form $H = 1.08$ m and during falling $H = 0.799$ m the flow become free surface flow.

① load on bridge foundation due to scour and their working mechanism.

Bridge scour::

Bridge scour is the removal of sediment such as sand and gravel from around bridge abutments or pier. scour, caused by moving water and it can scoop out scour holes, Compromising the integrity of a structure.

bridge scour is one the main cause of bridge failure. It has been estimated that 60% of bridge failure is due to bridge scour.

The type of rock or sedimentation carried by the river toward and away from the bridge. These area are also effected due to load on foundation (load of carried cement).

Mechanism of Scouring at bridge :-

When the water flow in river is deflected by obstruction like bridge piers, scouring would occur arising from the formation of vortexes. The mechanism of formation of vortexes is, the flow hits the bridge piers and tend to move downward. when the flow reaches the seabed, it would move in a direction opposition to its original flow direction before hitting the bridge pier.

Hence this moment of flow before the bridge pier result is the formation of a vortex owing to the formation of this vertical vortex, seabed material is continously removed so that holes are formed at the seabed and this result in local scour at the bridge pier